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# THE IMPACT OF COMPUTERS ON BOOK AND JOURNAL PUBLICATIONS

BY

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# The Impact of Computers on Book and Journal Publication

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ABSTRACT

Scientific books and journals characteristically have complex typography and small editions. Libraries are expensive and incomplete, and books and journals are increasingly costly. Computer-based photocomposition is used to compose scientific books and journals and makes possible parallel electronic publication at small cost. Development of commercial computer networks can reduce communication cost. Inexpensive minicomputer timesharing systems are available. Electronic publication is now technically feasible and cost effective. Electronic publication will increase scientific productivity for all scientists by reducing the cost and inefficiency of the current information system. The availability of network communication will enhance the quality and quantity of scientific communication. Computers have had a small impact on the publication of books and journals, but their future impact will be much greater. In a few years, computers will become the medium in which the bulk of the scientific and technical knowledge of the world will be published.

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# I. Introduction

Rising wages have made the cost of composition and printing of editions of a few thousand copies exhorbitant. Rising book and journal prices have contributed to the rising costs of libraries. At the same time, the volume of scientific and technical literature is increasing rapidly and the publication and library system is increasingly incapable of satisfying user needs.

Electronic publication of scientific and technical literature is technically feasible. One machine readable copy of a document may be stored on a computer and accessed by any remote user with a computer terminal. Current costs of preparing a machine readable text, storing it on a computer, communicating with the remote computer, and computer time for the user to read or print the document are low enough that for many applications in scientific publishing, a computer-based system may be somewhat less expensive than the existing paper-and-ink system.

Rapidly decreasing computer and communications costs indicate that electronic publication will be increasingly cost effective compared to alternative systems.

The benefits of a comprehensive electronic system for scientific and technical publication are substantial. Not only would the system be more complete and less expensive

than the existing system, but it would be more accessible. Many users who do not now have access to the scientific literature could use the system. An electronic system would increase scientific productivity. Not only would the scientist spend less time learning about what has been done, but he would obtain much more current information than is now available. Moreover, the computer-based scientific information system can provide a medium for two-way communications between users that is more convenient and effective than existing media.

## II. Publication of Scientific Books and Journals

A majority of the scientific publication is done by professional societies, universities, and government. Very few scientific books and journals sell more than a few thousand copies. Scientific literature is complex in terms of composition: it is characterized by many equations, tables, and diagrams. In many instances composition costs exceed printing and distribution costs.

Scientific literature is also growing rapidly. The stock of scientific publication has been estimated to increase at 7 per cent a year (Price, 1970). The total number of journals is increasing at 4 per cent a year (Barr, 1972).

The growth of scientific literature threatens to overwhelm readers. Libraries, cramped for space and short of money, cannot hope to provide complete coverage of the growing literature. Indexing and abstracting by computer may identify what is in the literature, but this makes the tasks of libraries more complex.[1] Interlibrary loan and

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[1] Many people believe that computer indexing and abstracting is not very reliable, efficient, or cost effective. Approaches such as Salton's SMART, written in appropriate languages and implemented on appropriate hardware can be extremely useful. It is important to distinguish between interactive systems which the user can direct and redirect to desired documents and batch systems in which a once-and-for-all request must be specified. An interactive system can be highly efficient in retrieving all desired documents, and is limited only by the user's

photoduplicates are increasingly called upon to provide missing documents, but seekers of current literature more often pursue the author by mail and request a reprint. As a result of journals such as Current Contents a completely parallel system of author to reader distribution has forced upon authors the burden and cost of distribution.[2]

A huge literature of technical reports has emerged (Brearley, 1973). Unreviewed, unread, and unsung (at least by promotion committees), technical reports are cited with increasing frequency. Most are unindexed and are consequently difficult to find, but federal government supported research reports are increasingly included in the National Technical Information System (NTIS), are indexed, and are readily obtained as microfiche, photocopy, or magnetic tape.

Attempts to stifle the growth of the literature create more problems than they solve. Proposals to tighten review-

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imagination in specifying objectives.

[2] An author has perhaps the right to hope that having paid submission, review or page charges for publishing his article he has done his part to finance dissemination. The heavy cost of distribution by reprints in some fields is burdensome for the author, but it is much cheaper for the requester than is interlibrary loan or subscribing to the journal. Requesters seem always to expect a copy free and postpaid and sometimes grow abusive when a charge is imposed. As it is, a reader with a stack of prepaid and preprinted post cards can build an excellent library at the expense of the authorsw.

ing and exclude literature from journal publication are idealistic but unrealistic. Authors must publish even if they have nothing to say, and, if necessary, they will create new journals.

Attempts to cheapen publication by using microfiche, separates, or abstract or condensed journals simply further fragment the literature and increase the gadgets and oddly-shaped cabinets in the library (Bovee, 1973; Staiger, 1973). These new media also increase the pressures on authors for direct distribution.

A scientific information system that is complete, unified, rapid, and cheap is the goal. Many people say, and some actually believe, that by the 1990's such a computerized scientific information system (SIS) will exist. Computers are considered to be too dumb, too small, and too costly to do the job today. They are thought to be too dumb to store and print the multilevel math, tables, and diagrams that fill technical writing. They are thought to be too small to store and access the trillions of characters required. They are thought to be too expensive to replace the existing paper, ink, and film system.

Many who have worked with computers agree with the criticisms, but those who live by computers can only agree secretly. There are a few huge data-base systems that can

be accessed interactively, but the wrecks of horribly costly systems litter the scene. There are successes too. Lockheed Information Systems offers in DIALOG a remarkable set of bibliographical indexes usable interactively by telephone or Telenet. The LEXIS system of Mead Data Central, Inc. provides on-line indexing and full retrieval of legal text for some states. Large data-base applications in business are widespread. Some firms have hundreds of terminals accessing a central computer and processing millions of transactions daily. Moreover, computer costs are decreasing rapidly. It is these recent developments that make an economical computer-based scientific information system possible.

## III. Composition of Scientific Books and Journals

Between Gutenberg in 1450 and Mergenthaler in 1886, hand composition experienced no significant technological change. Slug casting, or hot-metal composition, reduced production costs sharply. In 1890, Alfred Marshall's *Principles of Economics* sold for $4, a workingman's weekly wage, while in 1936, Keynes's *General Theory of Employment, Interest, and Money* sold for $2, a workingman's daily wage.

Book and journal prices remained remarkably stable for the first half of the century. Material and labor price increases were apparently offset by productivity change. Since 1950, prices increased, especially in the past decade. From 1967 to 1974, the price of hardcover books increased by 67 per cent (Brown, 1975). Periodicals increased even more. From 1967 to 1975, U.S. periodicals increased by 130 per cent, and increases were greater for chemistry and physics (214 per cent) and engineering (166 per cent). The large increases in the cost of scientific and technical periodicals show the influence of their typographical complexity.

Cost increases during the past two decades would have been even greater had not publishing technology improved.

Offset printing made it possible to reproduce simple typescript, but typescript is ugly. Lines are unjustified, letters usually the same width, and footnotes and tables are

unattractive. Strike-on composition with even margins was made possible with justifying typewriters, but more sophisticated strike-on composition is possible with new devices. Highly readable photocopy is obtained from justifying magnetic card or tape electric typewriters, computer terminals, or computer lineprinters.

Strike-on composition is inferior in speed and elegance to photocomposition which can solve all of the typographical problems of the compositor. Subscripts, superscripts, non-Roman alphabets, and several type sizes are readily composed. Phototypesetters incorporate computers or are driven as on-line computer peripheral devices.

Strike-on and phototypesetter composition, or "cold-copy composition," have been widely adopted. At best, the quality is unmatched. For pure text composition the cost can cost as little as $3 or $4 a page, or comparable to typewritten text composition. A typist, working with a computer text editor, can produce copy with speed and accuracy. With the economy and speed of offset printing, runs of a few hundred copies can be quite cheap.

Offset printing has contributed to the growth of scientific publication. In the 1960's, Praeger, using typewriter composition, produced a number of books from doctoral dissertations and technical reports. In the late 1960's,

Heath Lexington adopted cold-copy to produce justified-text books. The first of these were not very attractive. Footnotes dangled and white space was uneven, but libraries bought them and the publishers apparently made money.

During the 1960's cold copy was widely adopted by technical publishers. Today, text is set on a phototypesetter, sometimes aided by optical character readers,[3] but tables and equations are usually monotyped and proofed and stripped with the text photocopy to produce the page copy.[4] Composition combining photocopy, monotype, and typescript requires several suppliers and is slow and costly (Metzner, 1975). Moreover, the complexity of the process drives production managers wild. A fascinating history of composition of the American Institute of Civil Engineers

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[3] Optical character readers currently require the input of text retyped in readable characters on a typewriter with an OCR typeface. Even with retyping, costs are reported to be 20 per cent below straight photocomposition (Shirrell, 1975). OCR will become more sophisticated with the development of much greater computing power, so that multifont and later script input can be processed with reasonable accuracy.

[4] The trouble or expense in setting mathematical equations has led to the exportation of much of the mathematical typesetting to Europe. This is much cheaper for books, but it is obviously impractical for journals that attempt to be current. G. Wroughton of Superior Printing, Champaign, has developed a highly effective and high quality phototypesetter (using Alphatype as a foundation) that allows in-line setting of up to eight-level math that is used particularly for mathematical texts.

with examples is given by Parisi (1975).

Publishers agree that a completely computer-based composition system is needed and will take over the market as soon as available. It need not be very cheap. Publishers want speed, which a computer-based system could certainly deliver, and they want simplicity. Economy is important and would accelerate the adoption of computer photocomposition, but high quality appearance is necessary. Such systems exist.

and tables using special programs that can be learned in a few hours (Kernighan and Cherry, 1975).[6]

Once in the computer, the draft can be corrected by using special commands, such as "spell," which looks up every word in an on-line dictionary and produces a list of words not in the dictionary, and "typo," which uses the rules of English spelling (such as they are) to find possible typographical errors. Other programs have been written by various users to help authors improve their style. A word frequency command provides a list of words used in a document and a count of how many times they were used. Another program prints the lines in which some troublesome homophones (such as "there"-"their") or pet words (such as "obviously" and "clearly") occur so that a writer can avoid error.

The UNIX typist inserts commands to provide for centering, underlining, footnoting, equations, tables, indenting and other typographical specifications. The NROFF program then processes the file with text and interspersed command language and produces a decent looking, justified typescript (such as I hope this one is).

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[6] Equation typing on other systems is usually difficult or tedious (Korbuly, 1975).

UNIX also drives an on-line phototypestetter for a file with footnotes, tables, and equations. Bell Laboratories has a Graphic Systems C/A/T phototypesetter on-line. Using the editor program the typist (now become a compositor) inserts appropriate commands specifying font, special characters, and other typographical commands and produces a file that runs the phototypesetter through the TROFF program.

Three kinds of output files can be produced. A text without footnotes, superscripts, subscripts, or multilevel math can be printed correctly on a lineprinter. Text with these complications can be printed on a special printer, such as a Diablo. Text with phototypesetter commands interspersed can be printed on the phototypesetter. The lineprinter makes a mess of equations, superscripts and subscripts but prints text and tables. The Diablo prints superscripts, subscripts and equations. The Diablo ignores font changes and garbles or prints coded characters for non-Roman character sets (although it knows a little Greek). The phototypesetter sets everything. It is not difficult to write programs to convert a phototypesetter files to Diablo or lineprinter files.

The emergence of commercial computer-based phototypesetting means that the day of hot-metal or mixed-mode composition for technical publishers is ending.

## V. A Computer-Based Scientific Information System

No serious technical problems prevent development of a computer-based scientific information system (SIS). Computer-based photocomposition demonstrates that computers can store and print typographically complex documents.[7] On-line disk systems can store billions of characters, any of which can be accessed in milliseconds. Computers can be accessed remotely by telephone, or interconnected through data-communications networks. Computer timesharing allows hundreds of users to use the same computer interactively and simultaneously. SIS is technically feasible, but most people think the computer costs are too high to build one now. Computers are getting cheaper all the time (Soma, 1975). Any computer one buys is economically and technically obsolete by the time it is installed.

SIS, like any storage and retrieval system for scientific documents, must accommodate an enormous volume of ma-

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[7] Diagrams and line-drawings can be digitized and stored and printed on printers such as the Diablo or graphics scope terminals. Even half-tones or television frames can be stored and displayed. In terms of storage, a picture is worth considerably more than a thousand words. Non-Roman character sets, ideograms, or hieroglyphics can be either digitized or coded, or displayed on special terminals. The Teletype Model 37, for instance, can be equipped with an extended character set to type Greek or other letters. Doing these things in a commercial system is simply a matter of cost.

terial and low usage. Any such system is dominated by the cost of data input and the cost of data storage. Computer system costs are usually a small fraction of the total costs.

Computer-based photocomposition can reduce the cost of data entry substantially. Several publishers, such as the American Institute of Civil Engineers (Parisi, 1975) and the American Chemical Society (Metzner, 1975), are now using computer-based photocomposition to print their journals. Others, such as the American Institute of Physics, use computer composition for parts of the article, such as title, author, and abstracts. Multiple use of part of the material is increasingly common (Metzner, 1975). Machine readable abstracts are furnished to secondary journals and indexes. The full text could be stored on a computer and made available for anyone to read, if they wanted to read it.

It is said, I know not on what authority, that each article in a scientific journal is read 10 to 20 times in its life (Maxwell, 1973: 65). This statistic depresses authors and computer system designers alike. It hardly seems possible that it would be economical to rotate scientific literature of such limited popularity through eternity on computer disk with access time of a few milliseconds. But it is.[8]

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[8] Suppose one volume of a journal costs $25 and is

The telephone is cheap for local calls and costly for long distance. Economical electronic publishing requires minimization of the combined storage, communication, and computer cost. Storage costs are minimized with one copy on disk for everyone everywhere, and this requires use of long-distance telephone. To print a 10 page, 50,000 byte article might require 5 minutes using a common 30 character per second terminal. This could cost $1-$5 depending on the location of the reader and the computer and the time of day.[9]

The telephone line can transmit information faster than the terminal can type it, so either a faster terminal or a local computer to buffer the transmission and parcel it out in handy chunks for the terminal is required. Computer networks can cheapen data communications. The local computer,

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purchased and shelved by 100 libraries. This is a total cost of $2,500. Storing a hundred volumes requires about 10 square feet of library floorspace, or, at current construction costs, about $400. Thus the capital cost of the volume to the library system is $2,900. A volume is about 5 megabytes, or 1,000 pages of 5,000 bytes (or characters) each. An AED controller and disk system for 536 MB (formatted) costs about $75,000. This system would hold 100 of these journals (all, hopefully, different) for a cost of $750 per journal. Mass storage devices with much cheaper costs ( less than $1/MB) are commercially available, but for a distributed system using minicomputers storage a single system will not exceed a few hundred megabytes.

[9] This is cheap compared to costs of $7-$8 for interlibrary loan.

or host, is a line concentrator that receives messages (or documents) and stores them until the user wants them. Since the messages of many users are passing through a communications circuit simultaneously, each message (or "packet") must be labeled with identifying information. Research networks (such as ARPANET) and commercial networks (such as Telenet) using packet technology are operating and obtaining substantial economies in data communications.

Packet-switching networks like ARPANET and Telenet allow interconnection of dissimilar computers. A user of one system on the network can log into any other system and have his local system appear to be transparent. He can also ship files from his local computer to the remote computer, or _vice versa_. Minicomputers can be interfaced to a network without using any significant part of their memory or sacrificing much of their local processing power.[10] Packet-switching technology makes the cost of data transmission essentially independent of distance or intensity of usage. The user pays only for the data he actually transmits, although computer hosts must pay for occupying a permanent port on the network and users may pay a connect charge per hour to cover the costs of direct terminal access.[11]

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[10] For a clear, but technical, discussion of this, see Chesson, 1975.

Computer timesharing is a well-established technology, and almost everyone has used such a system or has stood by helplessly while one was used. Most timesharing systems operate on medium size computers costing several million dollars to support a few dozen simultaneous users. Some systems, such as PLATO IV, support several hundred simultaneous users in sophisticated (but computationally limited) applications. The cost of an hour of computer time usually depends on how much of the hardware is used, but commercial time on most full-size systems usually averages $10 to $25 a connect hour. Limited service systems, such as PLATO IV, may be able to provide services at a cost of $2-$3 an hour. The development of timesharing operating systems for low-cost minicomputers promises to reduce general purpose timesharing costs to $1-$2 an hour. Special limited purpose usage, such as that required from printing documents and inputting data should be somewhat cheaper.[12]

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[11] The current charge for Telenet is about $6/MB and $2/hr for connect time. A user accessing the network through a user host would pay the connect charge to that host and not the Telenet connect charge. The average cost of host-to-host data transmission is about $7/MB. This cost will be reduced substantially in the future.

[12] A Digital Equipment Corporation PDP11/70, supporting up to 32 simultaneous users, with 67 MB of AED disk, fast swap disk, 64k words of memory, and hardwire and telephone interfaces can be purchased for about $100,000. With the system running unattended, operating, space, and maintenance costs should not be more than $20,000 a year. If 25 per cent utilization were achieved (about 60,000 connect hours) the system could break even on a five-year depreciation schedule

Data input costs are very low for journals using computer-based photocomposition. New disk systems are cheap. Computer networking provides low-cost communications. Minicomputers can provide low-cost timesharing services.

A distributed SIS is emerging without any plan or central direction. Not only is DIALOG available on Telenet, but several universities (such as MIT) have computers on the network. Thus the indexing system and user hosts already are interconnected. All that is necessary for SIS to exist is that one or more publishers place their machine-readable texts on a network computer. An organization such as the American Chemical Society or IEEE could make part or all of their future publications available. Indexes could indicate the articles that were available and the host address. As journal hosts join the network, a computerized scientific information system will emerge.

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for about $.67/hr. for connect time. A system with hardware similar to the one described is operating at the University of California, Berkeley, and is informally reported to achieve the operating characteristics specified.

## VI. Impact of a Computerized Scientific Information System

A computerized scientific information system (SIS) is emerging. It promises eventually to cost less and be far more convenient for the user than the existing publishing and library system.

Computer cost trends suggest that we should not be niggardly in designing the system. A computerized system with the capability of two-way communications must not merely imitate the paper-and-ink system of today. SIS need not be a limited document storage and retrieval system. A network mail system will permit readers to comment on a document and the author to reply.[13] The comments and replies will be linked to the document file so that subsequent readers will be brought up to date on the state of discussion. Authors will also use the system to prepare and submit papers for publication, and editors and referees will use the system to speed publication by on-line reviewing, using the network mail system.

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[13] This facility exists on many timesharing systems as a message system. I typed this paper on CAC's computer system and sent a message to a colleague to comment on it. He copied it from my directory and sent his comments to me overnight. The network mail facility is in constant use over the ARPANET. Every registered user has a mail address, and a message is sent from a user on his own system by typing a command such as "netmail hugh at Ill-nts" followed by the message or file that is to be sent.

The mail facility will permit scientific publication to be quite rapid. A few days will suffice for refereeing, author's corrections, and copy reading and correction.

The system will become complete. A user will be able to access every document in the system from anywhere in the world. No journal will ever be in the bindery.

The system will have at least as much garbage in it as libraries do today, probably more, but the garbage will not clog the system. Computer-based indexing will guide a new breed of scholars to the literature. Review articles will tout the good and brand the bad. Users will retrieve everything bearing on a subject they wish to investigate deeply, or skim the cream by requesting only widely cited and reviewed articles. Inaccurate, slovenly, and plagiarized articles will be panned. At last it will be possible for authors to publish and perish at the same time.

The impact of SIS on authors and readers will be revolutionary. No document will be condemned to obscurity. No document will be hidden from a reader who wants it.

The impact of SIS on publishers will also be revolutionary. They will attempt, for a while, to collect a copyright fee, but ultimately SIS will become the exclusive system. Non-profit publishers who are only attempting to cover costs will find that modest page charges can cover the cost

of publication. Journals will wither away, until only the table of contents is left as evidence that the editors have approved publication.

Libraries will also wither away, their historic duty done. Perhaps we should call the local user host through which the user accesses the network to read and write a "library."

## VII. Conclusions

Developments in computer-based photocomposition now hold the promise of producing inexpensive photocopy from a single sequential file. In the process of producing this file, electronic publication of scientific literature becomes available as a low cost alternative to conventional distribution. Recent decreases in the cost of disk storage, timesharing computers, and the development of computer networking permit cheap storage, access, and transmission of text files. As a result, computer composition and electronic publication now appear to be less expensive than conventional publication.

To gain these advantages libraries should be prepared to participate as user sites and to install user network hosts to provide access to the network as electronically published journals become available. Publishers snould participate in developing the system by providing machine readable copies of their publications to experimental and demonstration systems.

The widespread adoption of electronic publishing will herald an important new day in science. The act of publication will become the first step in scientific communication, rather than the last as it too often is today. The scientific literature will become unified, reversing the recent

trend toward diverse forms of publication. Scientists everywhere can have equal access to the scientific literature, so that the advantages of being in a famous center of research will be substantially lessened. Scientists in obscure universities or poor countries will be able to participate in scientific discourse more readily.

When that day finally dawns, scientists will look back on the problems of authors, publishers, and librarians of today with sympathy. Let us hope that they will be grateful for the work that was done to make electronic publishing possible. Let us also hope that the disk system doesn't crash!

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